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FRAUNHOFER INSTITUTE FOR BUILDING PHYSICS IBP

ENERGY SYSTEMS

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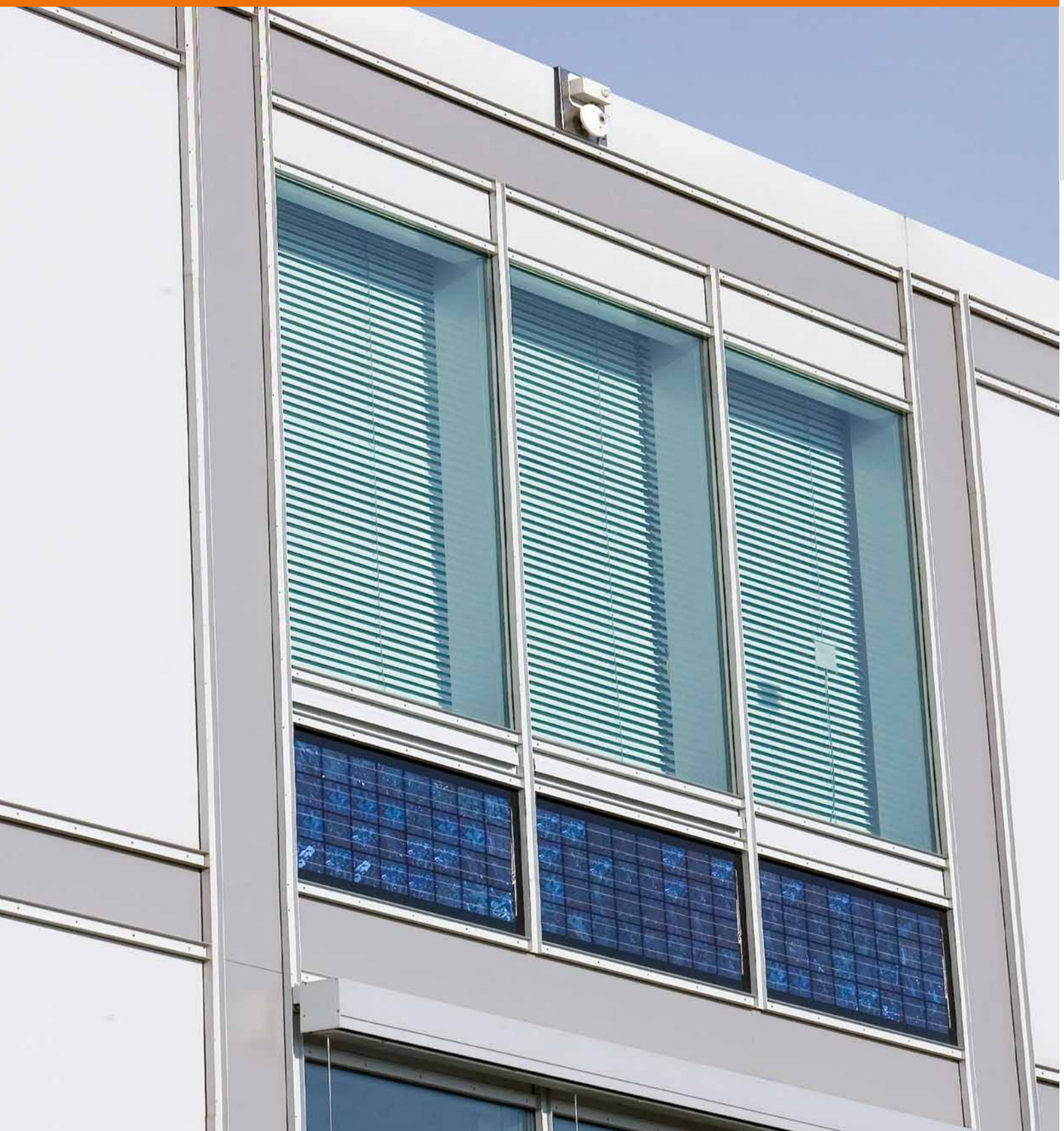

RESEARCH AND DEVELOPMENT IN THE FIELDS OF

- FAÇADE CONCEPTS
- SYSTEMS ENGINEERING
- LOW-EXERGY SYSTEMS
- HEATING AND CHIMNEY SYSTEMS

At its locations in Kassel, Stuttgart and Holzkirchen, the Energy Systems department conducts research and development on energy efficiency in buildings and their supply structures. The department's focus is on efficient energy-supply concepts, examining how to lower energy demands and how to cover residual demands in an energy-efficient way while including renewable energies.

Buildings, building envelopes and HVAC systems are considered in a comprehensive and integral manner in order to develop building services, façade systems and pre-fabricated building elements in a coordinated fashion.

Furthermore, concepts for integrating renewable energies to generate heat or cold or to utilize phase-change materials are being developed. In this area, the design and control of HVAC system technology as well as sun shading and lighting systems are the focus. Using our unique testing facilities these can be examined under real climate conditions and realistic usage scenarios on a 1:1 scale at the Institute's Holzkirchen campus.

In addition to the work on engineering building services, energy supply concepts for individual buildings and entire communities is another focal point for the department. Modern centralized as well as decentralized solid fuel stoves and their chimney systems must be operated efficiently and safely and be low in emissions while at the same time assuring comfort.

We research and develop measures to reduce exhaust gas emissions – especially that of particulate matter – through, for instance, filter and combustion optimization. We conduct experiments to determine and evaluate their operating behavior applying energetic, safety and environmental criteria. Our testing facility for stoves and chimney-systems at the Institute's Stuttgart location is flexibly certified by the DAP and plays a central role in this.

At the district level, procedures are developed to optimize energy consumption utilizing exergetic principles to evaluate energy applications accordingly. Of particular interest is the simulation of residential districts and communities in terms of energy systems and the optimization of energy demand at the building and community level. On the other hand, developing concepts for energy-efficient – all the way to CO_2-neutral cities and communities is of central interest to the researchers.

The research and development work of the Energy Systems department is supplemented by tests, simulations and demonstration projects.

Energy optimization of façades and building concepts in the testing facility for energetic and indoor climate testing (VERU) of the Fraunhofer IBP at the Holzkirchen location.

FAÇADE CONCEPTS

Development and energy evaluation of innovative building envelopes
The envelope of a building is the main interface to the outside world and defines the energy demands of a building and the comfort in the individual rooms. The Façade Concept Group will provide you with consultation services during the planning phase and will develop, together with industrial partners, new and innovative façade and roof designs. In Holzkirchen, the IBP has a modular test facility available for "energy and indoor climate investigations" (VERU), where façade systems can be studied together with the building's technical systems and their effects on the rooms behind the façade. The particular focus here is on an integral view of the energy coming in and going out through the façade, the energy required for heating, cooling and lighting, climatic and visual comfort and the interaction of façade technology with the technical systems of the building. This testing facility permits carrying out investigations on a 1:1 scale in real environmental conditions. In addition to the traditional building components, membrane constructions are a future market. Field tests are accompanied by laboratory measurements of materials' radiation characteristics in the accredited test lab.

Technical systems integrated into the façade
Modern façade designs can integrate numerous energy-supply systems, e.g. decentralized ventilation, systems to absorb solar radiation, PV modules, thermal storage devices as well as lighting units. The components to be integrated must be adapted to the special framework conditions of the façade and optimized for the intended areas of application.

Sun shading systems – their regulation and control algorithms
Not only do sun shading systems affect the energy demand for heating and cooling of buildings, the demand for artificial lighting also depends on the selection of the sun shading system. In addition, they greatly affect thermal and visual comfort - in particular, by their regulation and control behavior. The "VERU" facility provides the opportunity to test and analyze different sun shading systems and control algorithms on representative model offices under actual environmental conditions.

Simulating buildings and the technical systems in them
The metrological investigations taking place in the outdoor testing facilities of the IBP are supplemented by dynamic simulations as well as evaluation methods based on monthly balances. In particular, the measurements are used to validate and check the simulation models used.

1 *Section of the south façade of the test facility VERU – Test cell with post and beam façade construction and integrated photovoltaic modules as well as outside lamellar blinds providing shade against the sun.*
2 *View into a VERU test room: simulation of an office situation, with a full glass façade, closed sun shade and typical lighting system with basic measuring equipment.*

3 *View of the testing facilities of the Fraunhofer IBP in Kassel: Rig for assembled units of photovoltaic systems and test rooms for comparative measurements of summertime overheating in attics.*
4 *The demand and supply structures of cities and communities form complex dynamic structures. Their analysis must take spatial relationships into account along with quantitative energy and materials consumption.*

Exergetic method
The exergetic evaluation of energy conversion processes adds a qualitative element to the traditional approach to energy. Inclusion of exergy demand permits an evaluation that goes beyond considerations of energy efficiency in buildings or community systems. For example, the temperature levels of various supply systems and/or the exergetic potential of fossil and renewable fuels are integrated into the calculation. This approach goes beyond the quantitative treatment of energy demand and requires the inclusion of thermodynamic conditions.

Exergetic considerations are particularly useful in the optimization of supply concepts for heating and cooling at the community level as well as for the integration and layout of renewable thermal sources within supply grids. For this purpose, established calculations in simplified methods are refined and supplemented with exergetic quantities. Dynamic models are developed and used to represent complex dynamic processes.

Efficiency in context
Resolving matters of supply efficiency is particularly efficient in the context of larger systems. Here, cities and municipalities as well as utility companies are important project partners. In the system context, energy-supply concepts based on renewable energy sources offer great synergies. Local heating and cooling potentials can be utilized in combination and in cascades to achieve high exergetic efficiencies. The integration of various decentralized heating and cooling technologies makes the best use of existing potentials. Holistic energy concepts therefore interlink different demand and supply profiles in an optimized manner. The dynamic integration and load control of renewable energy, as well as the development of suitable buffer and storage systems, are key elements here. Sustainable local energy supply systems offer municipalities and cities the option of greater independence from fluctuating energy prices and an increased net local value.

Mapping complexity
Urban and community energy systems are complex dynamic structures. Suitable geo-information tools are utilized for the long-term verification of strategies, for checking the effectiveness of measures and to analyze the structure of energy requirements as well as energy supply. This way current potentials can be indentified and relate to each other. Taking into account spatial relation permits developing concepts that optimize energy and exergy demands for a sustainable city development.

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SYSTEMS ENGINEERING

Development and evaluation of energy supply concepts
The energy demand of buildings and complexes of buildings are determined mainly by the type of construction, the size of the buildings, the materials used, the buildings' envelope and the buildings utilization as well as the integrated technical building systems and control. During the planning phase of building projects Fraunhofer IBP develops innovative energy-supply concepts to minimize energy demands using an integrative approach. The consultancy comprises the highest possible integration of "renewable energies" into the overall concept. During developments, dynamic simulation programs are used in addition to methods based on monthly balances, like evaluation tools for the German Building Energy Standard (DIN V 18599). For the comprehensive assessment of properties after completion, the IBP offers building evaluations, which include preparation of measurement concepts, monitoring and data analysis.

Innovative retrofitting concepts
Existing buildings pose a particular challenge for reducing energy consumption in the building sector. To tackle this challenge, the Systems Engineering Group develops new concepts for refurbishing buildings in close cooperation with partners in industry. These retrofitting concepts are characterized by a simplified construction process, optimized integration of technical systems in the building and high product quality. The approaches investigated comprise the use of pre-fabricated large-format elements and are combining the building's envelope and the technical systems of the building into one module.

Development and evaluation of technical components
In the building sector, demand remains high for the development of technical components for heating, ventilation and air conditioning. The building systems engineers develop and evaluate, in cooperation with partners from industry, innovative components and systems that provide increased energy efficiency and user comfort. Developments are carried out using theoretical approaches, simulations of components or systems and measurements in the laboratory as well as our outdoor test facility and on real buildings.

Investigations of the thermal behavior during summer
In the future, given climate changes and increased user demands, the share of energy consumption devoted to cooling of buildings will increase. The goal here is to improve the thermal behavior of buildings during the summer using structural and building services concepts. To achieve this building components are evaluated regarding their energy and indoor-climate effects by means of comparative investigations. Components include ventilation, heating and air-conditioning systems as well as passive elements like phase-change materials or new types of insulation materials.

5 *System for heating, ventilation and air conditioning with corresponding distribution systems.*
6 *Wood burning during inspection of a bakery oven.*

HEATING AND CHIMNEY SYSTEMS

Development and evaluation of low-emission stoves and filters
Modern stoves for burning solid fuels, in particular split wood logs and wood pellets, together with their exhaust systems, must be operated in an efficient, safe way while maximizing user comfort and minimizing emissions. The activities focus on research and development to reduce exhaust emissions, in particular those of fine particulate matter. Porous ceramics filters invented jointly by the Heating and Chimney Systems group of the Fraunhofer IBP and the Fraunhofer Institute for Ceramic Technologies and Systems IKTS in Dresden, Germany, are used in stoves and fireplaces where split logs are burned as well as in exhaust-emission systems. To optimize the burning processes in stoves their operating behavior and interaction with exhaust-emission systems is assessed experimentally and evaluated in accordance with criteria relating to energy, safety and environmental factors.

Testing Laboratory Stoves / Chimney Systems
The Testing Laboratory Stoves/Chimney Systems performs official tests, feasibility studies, suitability tests and quality tests for solid- and liquid fuel stoves and their exhaust systems and also develops new testing methods (see accredited testing facilities).

ACCREDITED TEST FACILITIES

Technical radiation characteristic data (Holzkirchen)
Spectral measurements of solar transmissions and reflection of homogenous, transparent and opaque samples:
- total solar radiation 280 to 2,500nm with a two-ray grid spectrometer
- thermal radiation 2,500 to 50,000nm with a Fourier spectrometer; determination of photometric and physical characteristics.
- transmission, reflectance and absorptance in accordance with DIN EN 410
- thermal transmission, reflectance and emittance
- total energy permeability of multiple-layer glazing in accordance with DIN EN 13363 and DIN 410
- Color reproducibility index in accordance with DIN 6169 or DIN EN 410
- Heat permeability coefficient of buildings in accordance with DIN EN 673
- Visual and thermal comfort in accordance with DIN EN 14501

Stoves/Chimney Systems (Stuttgart)
Testing Laboratory for stoves for solid and liquid fuels
- EN 12809 Boilers
- EN 12815 Stoves
- EN 13229 Inset fireplaces
- EN 13240 Room heaters
- EN 15250 Slow heat-release appliances
- EN 14785 Room space heaters fired with wood pellets
- EN 1 Heaters for liquid fuels

Testing, monitoring and certification laboratory for exhaust gas systems
- EN 1457 Ceramic flue liners
- EN 1856 Metal flue liners
- EN 1858 Concrete flue blocks
- EN 12446 Outside concrete envelopes
- EN 13063 Chimneys with ceramic flue liners

Special testing facilities
- Calorimeter room to determine the thermal performance of heat-retaining firing systems/stoves
- Test stand for measuring the concentration and the size distribution of particulate matter in hot exhaust gases

Accreditations
- flexible accreditation by DAP in accordance with DIN EN ISO/IEC 17025
- notified body in accordance with the German Building Products Act (Bauproduktegesetz) (CE symbol)
- Testing facility according to the building regulations of the German states ("Ü" symbol)
- Testing facility DIN CERTCO (DINplus symbol)
- Testing facility in accordance with the Equipment Safety Act ("GS" symbol)

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